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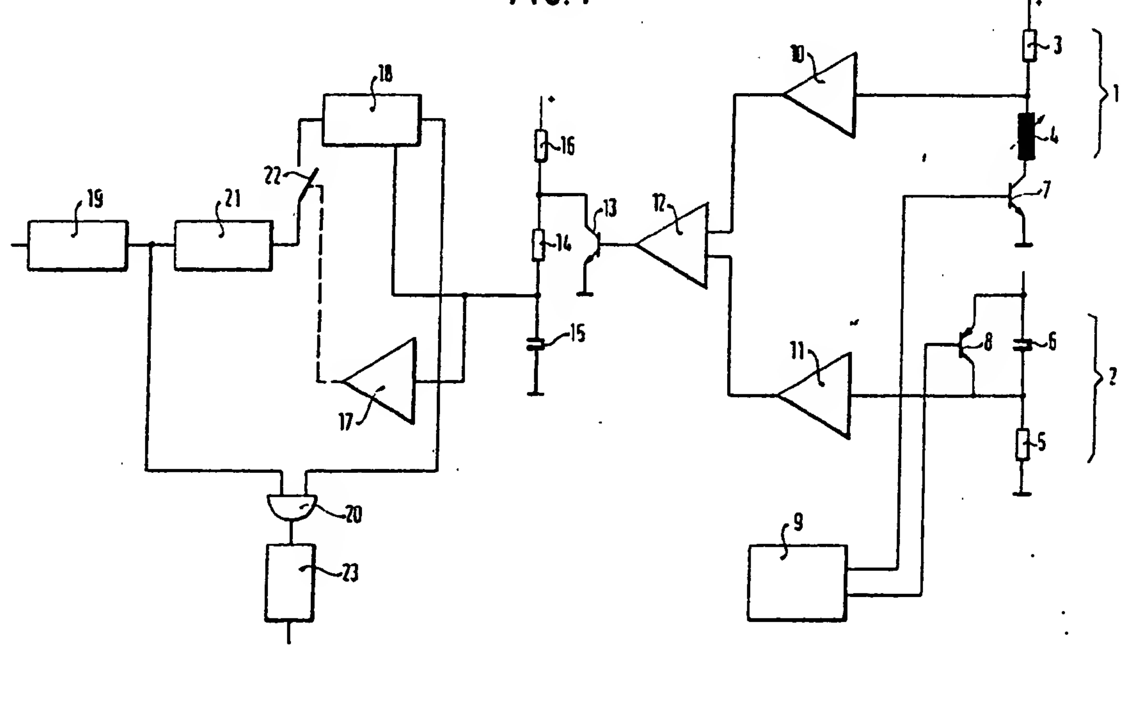
(54) Controlling fuel injection or ignition timing of engines

(57) A circuit for controlling fuel injection or ignition timing in dependence on atmospheric pressure comprises a first time constant circuit 1 including an inductance 4 which varies with atmospheric pressure and a second time constant circuit 2 which provides a constant signal representative of a datum pressure. A clock pulse generator 9 controls transistors 7,8 so that comparators 10,11 receive pulsed signals which are compared with a threshold level. The pulse outputs of the comparators are supplied to a NAND gate 12, the output of which is a signal having a pulse width proportional to the difference between atmospheric pressure and the datum pressure. This signal may be used directly to control fuel injection or ignition timing or alternatively it may be supplied to a circuit 13–23 which receives ignition pulses and controls an ignition coil connected to a pulse shaper 23.

FIG. 1



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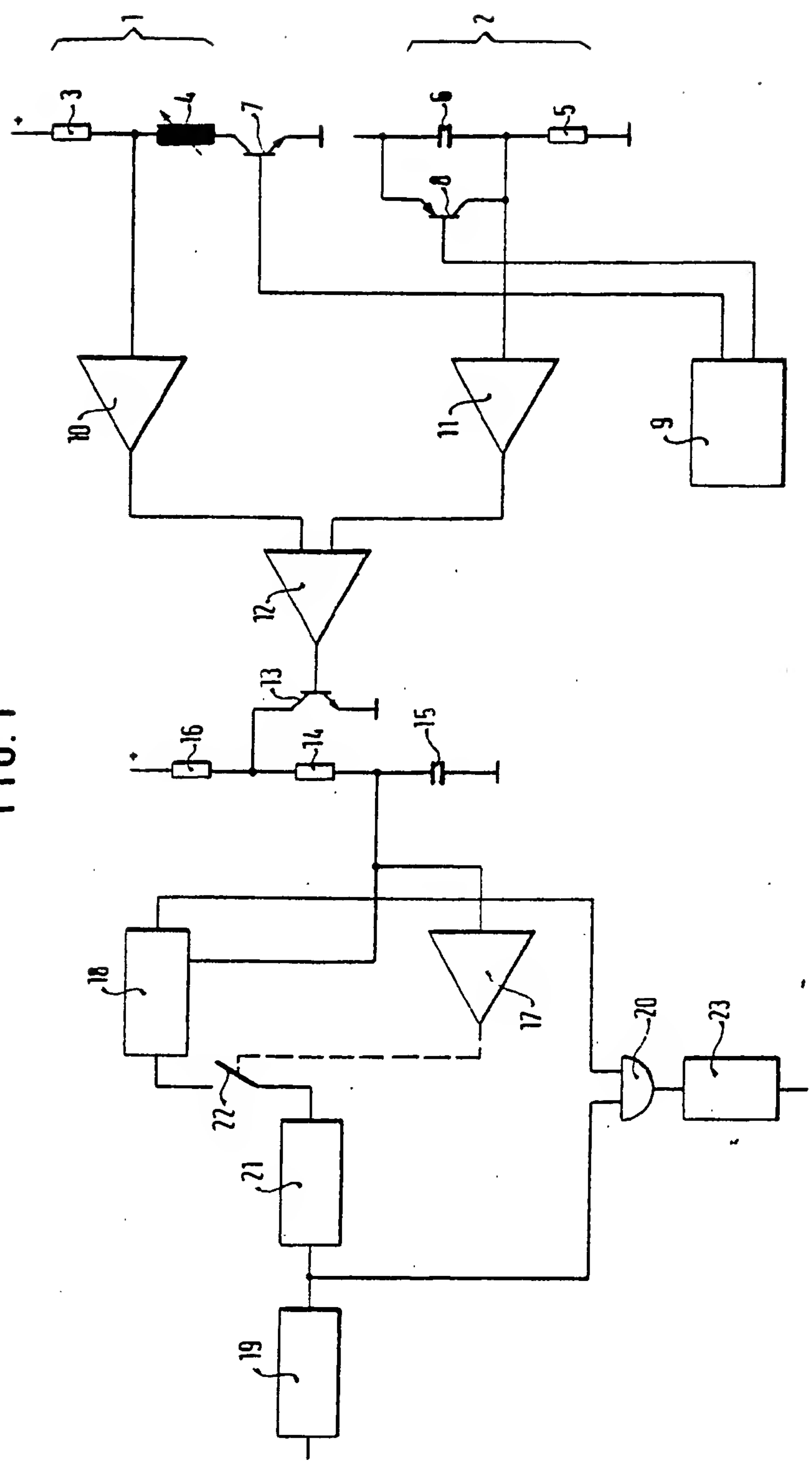


FIG. 1

FIG. 2

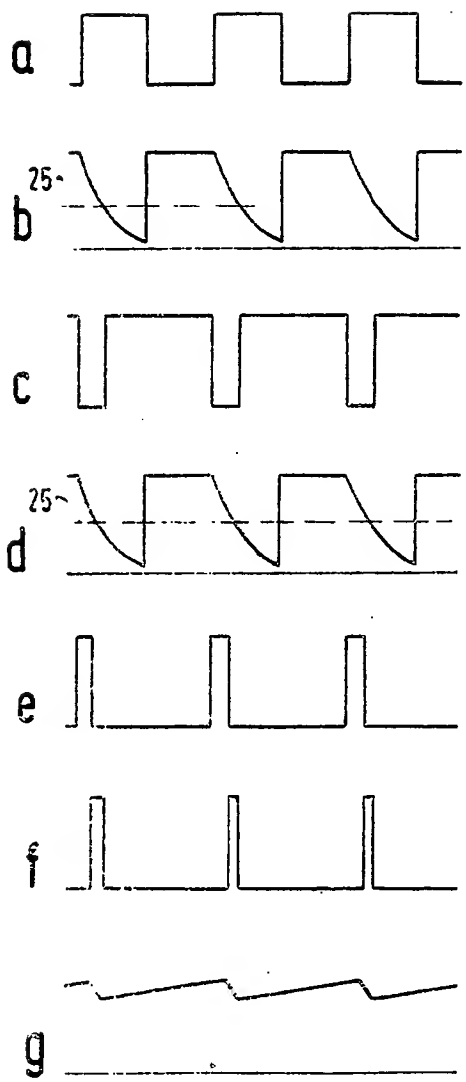


FIG. 3

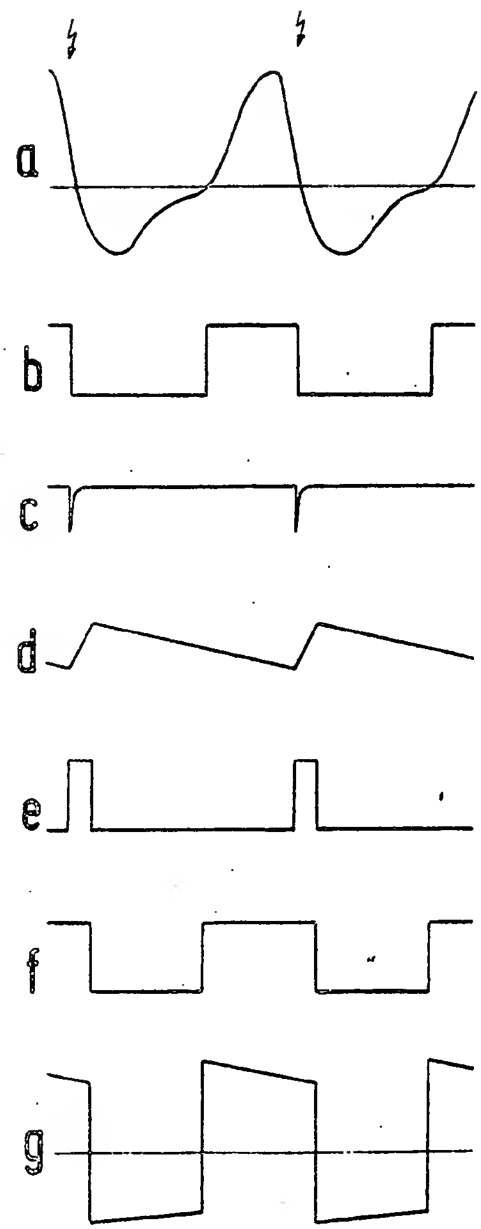
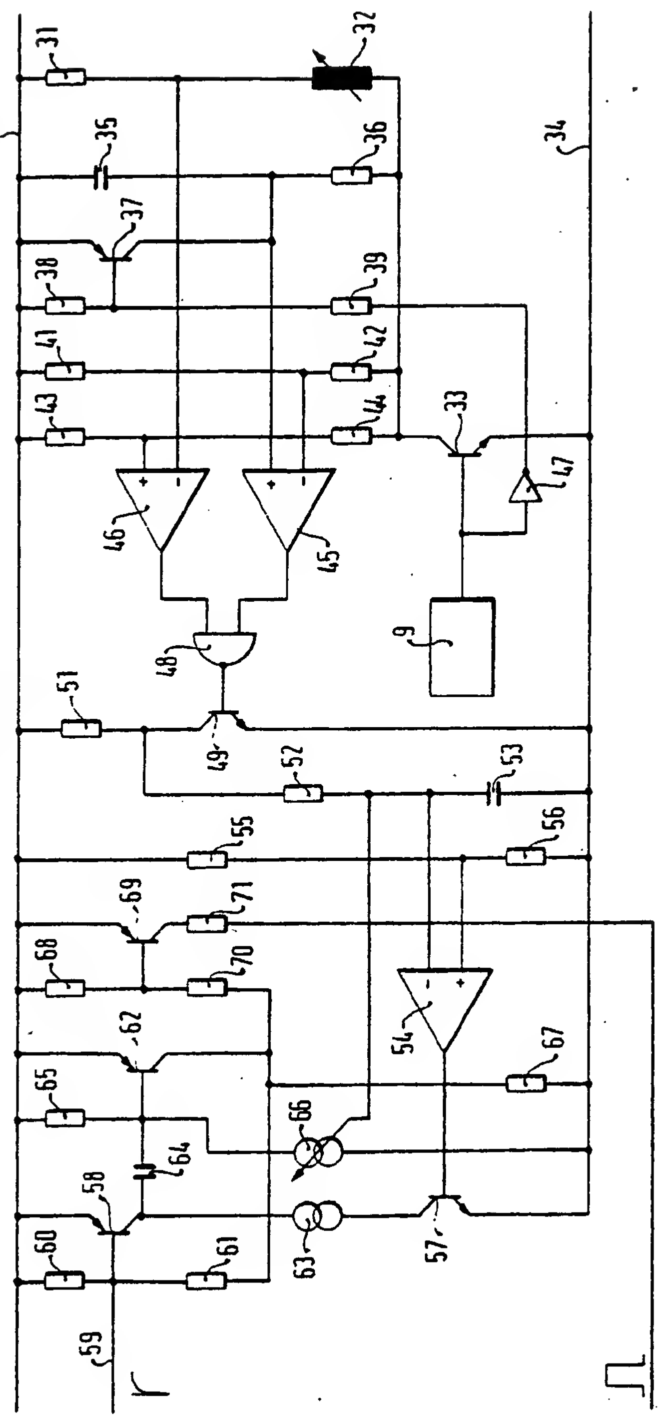


FIG. 4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SPECIFICATION

Pressur dependent adjustment of perating param ters of combustion engines

State of the art

The invention originates from a pressure dependent adjustment of operating parameters of a combustion engine according to the preamble to the main claim. From United States Specification 4 009 699, a digital electrical ignition system is known in which the ignition is adjusted in accordance with pressure. Moreover, for measuring the atmospheric pressure, a pressure converter is proposed which delivers a current proportional to the pressure which is converted into a digital signal by means of an analogue digital converter. Moreover, it is known to undertake a pressure dependent adjustment with an injection system. In that case, the pressure sensor acts on a potentiometer the centre tap of which is adjusted in accordance with the pressure.

These arrangements have the disadvantage that an analogue signal is available as a measure of the pressure. With digital ignition arrangements, the signal must be converted into digital pulses by means of an analogue digital converter. With pressure converters driven by potentiometers, there is the disadvantage that the potentiometer tracks are easily dirtied especially when operating in motor vehicles. Moreover, the spring pressure of the slider must be overcome. This means that a particular force must be applied by the pressure sensor proper in order to move the slider. This is of particular disadvantage when only slight pressure differences, as for example atmospheric pressure, are involved. Dirt on the slide tracks and the necessary forces for adjusting the potentiometer slider lead to false indications at the output from the pressure sensor and to an hysteresis.

Advantages of the invention

As opposed to this, the arrangement in accordance with the invention comprising the characterising features of the main claim has the advantage that, on the one hand, pulses dependent on pressure are already available for digital ignition systems and on the other hand, inductive or capacative sensors can be used which operate completely without friction. The influence of dirt is of no consequence with these sensors.

Advantageous further developments and improvements of the arrangement for pressure adjustment set forth in the main claim are made possible by the m asur s set forth in the sub-claims. For generating continuous pulses, it is of advantage to charge and discharge the timing elements by means of electronic switches. In that way, the precise establishment of starting conditions is possible so that the measurement is considerably more accurate than if the natural discharge of the inductances or capacitances were to be awaited. By means of the comparators connected after the timing elements it is possible to trigger pulses at a definite predetermined condition of charge of the timing elements. In order to provide a pulse which is directly proportional to the measured pressure, it is preferable to subtract the pulses from the two comparators from one another. This can be achieved in a simple manner by a NAND element. If, instead of a digital pulse, an analogue signal proportional to the pressure is required in order to operate the circuit arrangement including analogue circuits, then an integrating element which converts the pulse into a DC voltage is connected after the NAND element. A multivibrator, for example, is controllable by means of such a DC voltage to deliver pulses for an ignition system or an injection system. Moreover, the simplest way of producing the pulse time or the pulse ratio of the multivibrator is by controlling the current of the multivibrator. The electronic switches for the timing elements are preferably controlled by a clock generator which either oscillates freely or is controlled externally when pulses are to be delivered by the pressure measuring device at particular times.

Drawing

An embodiment of the invention is illustrated in the drawing and is described in detail in the following specification.

Figure 1 shows a block circuit diagram of an air pressure dependent retarding of an ignition system,

Figure 2 is a diagram for explaining the function of the pressure measuring device,

Figure 3 is a diagram for explaining the control of an analogue ignition system by means of the pressure measuring device and

Figure 4 is a practical embodiment of an ignition system provided with a pressure measuring device according to the invention.

Description of the invention

In the block circuit diagram according to Fig. 1, the timing elements 1 and 2 each have a resistor 3 or 5 and one has a variable inductance 4 and the other a capacitor 6. The resistor 3 is connected in series with the variable inductance 4 whereas the capacitor 6 is connected in series with the resistor 5. The other ends of the resistor 3 and of the capacitor 6 are connected to the supply voltage whereas the other end of the resistor 5 is connected to earth. Th inductance 4 is conn cted to earth through the collector emitter path of a transistor 7. The inductanc is made variable by pressure. For this purpose, the iron core of the inductance 4 is made movable, for example, and is connected to the diaphragm of a barometric box which displaces the core within the coil in accordance

with the pressure. The collector emitter path of a transistor 8 is connected in parallel with the capacitor 6. The bases of the transistors 7 and 8 are connected to the clock generator 9. Between the resistor 3 and th inductance 4, a line leads to a comparator 10 whilst the input to a comparator 11 is connected between the capacitor 6 and the resistor 5. The outputs from the comparators 10 and 11 lead to the input to a differential pulse shaper 12 which, in the simplest case, is formed as an AND element. The output from the differential pulse shaper 12 leads to the base of a transistor 13. The series circuit comprising a resistor 14 and a capacitor 15 is arranged in parallel with the collector emitter path of the transistor 13. The emitter of the transistor 13 and one end of the capacitor 15 is connected to earth whereas the collector of the transistor 13 is in communication with the supply voltage through a resistor 16. A line which, on the one hand leads to a comparator 17 and on the other hand to a multivibrator 18, is connected between the resistor 14 and the capacitor 15. A line from an ignition pulse generator (not shown) leads to the pulse shaper 19 which, on the one hand, is connected to an AND element 20, on the other hand is connected to a differentiator 21. The output from the differentiator 21 leads through a switch which is controlled by the comparator 17 to the synchronising input to the multivibrator 18. The output from the multivibrator 18 is connected to a further input to the AND element 20. The output from the AND element 20 leads to a pulse shaper 23 to the output from which is connected the ignition coil (not shown).

The method of operation of the pressure adjustment will be explained with the aid of the pulse diagram according to Figs. 2 and 3. The transistors 7 and 8 are switched alternately into the conducting and blocking condition by the clock generator 9 which delivers pulses according to Fig. 2a and can be externally controlled. If transistor 7 becomes conductive, the current through the inductance 4 increases in accordance with an e-function. During blocking of the transistor 7 the full operating voltage lies between the resistor 3 and the inductance 4. The voltage curve at the input to the comparator 10 then corresponds to Fig. 2b. The operation at the capacitor 6 proceeds in a similar manner. If the transistor 8 is blocked then the capacitor 6 is charged at the supply voltage. The voltage falling at the resistor 5. which is applied to the comparator 11, then falls exponentially. If the transistor 8 is conductive then the operating voltag is applied to the input to the comparator 11. The voltage curve at the resistor 5 is illustrated in Fig. 2d. Whilst the falling voltage at the resistor 5 is not altered beyond the time of blocking of the transistor 8, since the time constant of the timing element 2 is always the same, the curve of the falling voltage at the coil 4 depends on its inductance. The comparators 10 and 11 are so designed that, at the beginning of the voltage drop, they change their condition and on reaching a threshold 25 they flip back into the original condition. A practical arrangement of one such comparator will be described with the aid of Fig. 4. At the start of the falling voltage, the comparator 10 flips from the 1-condition into the 0-condition and when it has fallen below a predetermined threshold it flips from the 0-condition into the 1-condition. At the start of the fall in voltage the comparator 11 goes from the 0-condition into the 1-condition and when the voltage has fallen below the threshold 25 it goes from the 1-condition into the 0-condition. The pulses thus formed at the output from the comparator 10 are depicted in Fig. 2c, the pulses prevailing at the output from the comparator 11 are depicted in Fig. 2e. In order to achieve the most accurate results possible, the switching threshold 25 for the comparators is arranged as low as possible since thereby the pulses are long. The reaching of 63% of the final value of the voltage is recommended as the threshold level which corresponds substantially to the time constants of the timing elements 1 and 2.

The signal at the output from the comparator 10 is made up of a basic value which corresponds to the basic inductance at the lowest pressure and of a component which is dependent on the change in pressure. Whilst it is already possible with one component of digital circuits to evaluate this pulse in binary form, because the basic inductance is taken into consideration by subtraction of a binary value corresponding to the said basic inductance, a subtraction of the pulse component which corresponds to the basic inductance, is necessary with other circuit arrangements. The pulse prevailing at the output from the comparator 11 according to Fig. 2e serves for this purpose and is so selected that its pulse length corresponds exactly to the basic inductance. Since this pulse is likewise conducted through a time constant there is the advantage that the pulse processing is independent of any variations in the supply voltage since only the time period of the discharge procedure of short duration is important. Although the output pulses from the comparator 10 and from the comparator 11 can be selected as desired the advantage is provided with the selected output combination according to Figs. 2c and Figs. 2e that the difference pulse can be derived in the differential pulse shaper 12 by a NAND gate. If the differential pulse shap r 12 is designed as a NAND elem nt a pulse according to Fig. 2f is produced at the output from the NAND element. The length of this pulse is proportional to the pressure difference, with respect to the pressure at which

the inductance has its basic inductence.

These differential pressure pulses can be used directly for controlling a digital ignition device or a digital injection system. By a suitable selection of the threshold value their length is also variable within certain limits so that they can be directly associated with the pure ignition pulse or injection pulse to provide an adjustment. If the pulses require a specific beginning or a specific end then it is possible to synchronise the clock generator 9 externally.

If analogue signals proportional to the pressure difference are required, then this is achieved by the fact that they are negated by the transistor 13 and are integrated at the capacitor 15. The falling voltage at the capacitor 15 is illustrated in Fig. 2g and is inversely proportional to the pressure difference. Analogue operating ignition systems or injection systems can be controlled with this signal.

Furthermore, an ignition system is provided, for example, which serves for reducing the fuel consumption at a particular output and to locate the ignition instant always close to the pinking limit whilst simultaneously making the mixture leaner. In so doing, a higher air pressure, for example at sea level with respect to mountains, leads to a greater filling of the cylinders. The result of this is advanced ignition (pinking). In order to compensate, the ignition instant needs to be reterded in accordance with the absolute air pressure. The pressure measuring device described above is especially suitable for measuring the air pressure and for ignition retarding. The same problem applies with fuel injection.

With analogue ignition systems, the signal coming from the pulse generator and illustrated in Fig. 3a arrives at the Schmitt trigger 19 which switches during the 0-passage of the signal. This signal is applied to the AND element 20 and is illustrated in Fig. 3B. The negative flank of the triggered signal is differentiated by the differentiating member whilst the positive flank is suppressed. A signal according to Fig. 3c is present at the output from the differentiating member 21. With the switch 22 closed, which can be for example designed as a transistor switch, the differentiated signal trips the multivibrator 18 the pulse ratio of which is determined by current sources. One current source for the multivibrator 18 is controlled by the voltage applied to the capacitor 15, so that the charging and discharging operation of the pulse determined capacitor, which is illustrated in Fig. 3d, is dependent on the pressure difference. The pulse shaped by a buff r and which is provided by the rising flank illustrated in Fig. 3e, is proportional to the pressur difference and synchronised in accordance with the ignition pulse sequence. By these measures the condition is not achieved wherein the difference pressure pulse is applied to the ignition pulse but on the other hand the pressure dependent pulse is varied in accordance with the speed of the combustion engine so that it always covers a constant rotary angle during one crankshaft rotation even at a constant pressure. The ignition pulse according to Fig. 3b and the pressure dependent pulse according to Fig. 3e are summed in the AND element 20 at the output from which a retarded pulse according to Fig. 3f prevails. This signal is so processed by the pulse shaper stage that it can serve for controlling the ignition coil (not shown). Such a signal is illustrated in Fig. 3g.

Should the ignition retard become 0 then the multivibrator current controlled by the pressure wuuld need to move towards infinity. With ectual arrangements this is not possible because there must always be a predetermined duty ratio so that a certain adjustment would always remain. Thus, the comparator 17 senses the voltage dependent on the pressure and switches over on exceeding a predetermined voltage. Thus, the pulses which are delivered by the multivibrator ere suppressed. This is illustrated diagrammatically by the switch 22. Adjustment pulses according to Fig. 3e are not then delivered by the multivibrator so that an uncorrected ignition signal according to Fig. 3b is epplied to the pulse shaper stage 23. Thus, the remaining adjustment can be omitted with such a snap action.

Fig. 4 shows a specific embodiment of the essential parts of an arrangement according to the invention for an air pressure dependent retarding of the ignition. A resistor 31 which is connected on the one hand to e variable inductance 32, is connected to the supply voltage line 30. The variable inductance 32 is connected to the collector of a transistor the emitter of which leads to the common earth line 34 which also leads to the negative supply voltage. Moreover, a capacitor 35 leads from the supply voltage line 30 and is likewise connected through a resistor 36 to the collector of the transistor 33. The collector-emitter path of a transistor 37 is connected in parallel with the capacitor 35. The base of the transistor 37 is in communication, on the one hand, through a resistor 38 with the supply voltage line 30 and on the other hand it leads to e further resistor 39. In addition, the resistors 41 and 42 and the resistors 43 and 44 are connected in series between the supply voltage line 30 and the collector of the transistor 33. Between the resistors 41 and 42, a tapping leads to the negative input to an operational amplifier 45 designed as a comparat r. Between the resistors 43 and 44 a tapping leads to the positive input to an operational amplifier 46 designed as a c mparator. The negativ input to the operational amplifier 46 is connected to the lin between the resistor 31 and the inductance 32. The positive input to the operational amplifier 45 is in communicetion with the

connecting line between the capacitor 35 and the resistor 36. On the one hand, the clock generator 9 supplies the base of the transistor 33 and on the other hand it is in c mmunication through a negative element 47 with the resistor 39. The outputs from the operational amplifiers 45 and 46 are in communication with the inputs to the NAND element 48. The output from the NAND element leads to the base of a transistor 49 the emitter of which is connected to the common earth line 34. The collector of the transistor 49 leads through a resistor 51 to the voltage supply line 30. Moreover, a resistor 52, which on the one hand is in communication through a capacitor 53 with the common earth line, is connected to the collector of the transistor 49.

The negative input to an operational amplifier 54 arranged as a comparator is connected between the resistor 52 and the capacitor 53. The positive input to the operational amplifier 54 is in communication with a resistor 55 and a resistor 56 wherein the resistor 55 is connected to the supply voltage line 30 and the resistor 56 is connected to the earth line 34. The output from the operational amplifier 54 leads to the base of a transistor 57.

The output 59 from the differentiating element 21 illustrated in Fig. 1 and which delivers pulses according to Fig. 3c. is connected to the base of a transistor 58. A resistor 60 is connected between the base of the transistor 58 and the supply voltage line 30. Moreover, a resistor 61 leads to the collector of a transistor 62. The emitter of the transistor 58 is in communication with the supply line 30 whilst the collector leads to a current source 63. Moreover, the current source 63 is connected through the collector emitter path of the transistor 57 to the earth line 34. Furthermore, a capacitor 64 which, on the one hand, is in communication with the base of the transistor 62. is connected to the collector of the transistor 58. A resistor 65 is arranged between the supply voltage line 30 and the base of the transistor 62. Furthermore, a controllable current source 66 which is in turn connected to the earth line 34, is connected to the base of the transistor 62. The control of the current source 66 takes place through the voltage prevailing between the resistor 52 and the capacitor 53 and which is depicted by the connection of the control arrow of the controllable current source 66 to the line between the resistor 52 and the capacitor 53. A further resistor 67 leads from the collector of the transistor 62 to the earth line 34. A resistor 68 which leads to the base of a transistor 69 is connected to the supply voltage line 30. A further resistor 70 leads from the base of the transistor 69 to the collector of the transistor 62. A resistor 71 leads from the collector of the transistor 69 to the AND gate 20, not illustrated in this figure but shown in Fig. 1. A pulse according to Fig. 3e is applied to the said line. The supply voltage line 30 is applied to th emitter of the transistor 69.

The transistor 33 is switched alternately into the conducting and non-conducting condition by the cl ck generat r 9. If the transistor 33 is in the non-conducting condition, then, apart from a certain residual current, no currents flow through the voltage dividers 43 and 44 and 41 and 42 or through the timing elements 35 and 36 and 31 and 32. If the transistor 33 is blocked then the transistor 37 is maintained conductive by the negating element 47 so that the capacitor 35 is discharged. Thus, substantially the supply voltage 30 is applied to the inputs to the operational amplifiers 46 and 45. By suitable selection of the voltage dividers comprising the resistors 43 and 44 and the resistors 41 and 42, a voltage is established at the output from the operational amplifier 46, taking residual currents into account, with the transistor 33 blocked, whereas no voltage is present at the output from the operational amplifier 45. If the transistor 33 is then changed into the conducting condition, transistor 37 is blocked. Due to the voltage dividers comprising the resistors 43, 44 and 41, 42. a current flows which reduces the voltage at the positive input to the operational amplifier 46 and at the negative input to the operational amplifier 45. Shortly after switching on, the two other inputs to the operational amplifiers 45 and 46 once again conduct substantially operating voltage which, due to the charging of the capacitor 35, or the current through the inductance 32, falls exponentially with respect to time. Due to the variation of the voltages present at the voltage dividers, the operational amplifiers 45 and 46 change their state that is to say, on opening of the transistor 33, the operational amplifier 46 receives no signal at the output whereas a signal is delivered at the output by the operational amplifier 45. If, during the course of time, the voltages at the timing elements fall below the threshold 25 predetermined by the voltage dividers, the operational amplifiers 45 and 46 designed as comparators switch back into their original condition. The exceeding of the threshold after blocking of the transistor 33 has no further effect since previously the voltage dividers comprising the resistors 43, 44 and 41, 42 are switched, so that the reference voltage is raised. The output signal present at the operational amplifier 46 is always proportional to the inductance as regards its time period and is thus proportional to the air pressure. Since even at the lowest air pressure at which the ignition retard must be 0, a basic inductance is still provided, a time period corresponding thereto must be subtracted. This signal is present at the output from the operational amplifier 45 and is likewise generated over an e-function which is provided by the timing element comprising the capacitor 35 and the

resistor 36. Thus, the outputs from the two operational amplifiers are gated by th NAND gate 48. A pulse, the length of which is directly proportional to the air pressure difference (relatively to the pressure at which the adjustment must be 0) is produced at the output from the NAND gate 48. The pulses which are proportional to the pressure difference are negated by the transistor 49 and are integrated by the capacitor 53. The longer is the pulse delivered by the NAND element 48, the more is the capacitor 53 discharged through the resistor 52. During the remaining time, the capacitor 53 is charged through the resistors 53 and 52. Thus it can be said that the voltage at the capacitor 53 is inversely proportional to the air pressure difference.

Of the ignition system proper, only the multivibrator with the electronic switch is illustrated since the other components correspond to the normal electronic ignition equipment. Due to the negatively differentiated pulses according to Fig. 3c which are present at the input 59 to the multivibrator, the multivibrator, which consists of the transistors 58 end 62, the capacitor 64 and the current sources 63 and 66, switches over. Due to the switching operation, the capacitor 64 is charged by the current source 63 in accordance with Fig. 3d. The current source 63 delivers a constant current. The resistor 61 provides feedback for the multivibrator so that it switches after reaching a predetermined charged condition. Thereafter, the cepacitor is discharged through the current source 66. The current, which is delivered by the current source 66, is determined by the voltage at the capacitor 53. The current from the current source 66 is proportional to the pressure difference. Thus, the pulse ratio of the multivibrator is dependent on the ratio of the currents from the current sources 63 and 66 with respect to each other. In this instance, the current sources 63 and 66 ere only shown diagrammatically; known current sources can be used as desired. The pulses are buffered by the transistor 69 and serve for retarding known ignition systems wherein the delivered pulse is summed additively with respect to the original ignition pulse.

If the ignition is to be retarded to 0, then the discharge current controlled by the pressure must proceed towards infinity. However, that cannot be reached so that a certain adjustment always remains. The operational amplifier 54 designed as a comparator senses the voltage dependent on the pressure and switches over on reaching a predetermined voltage. The predetermined voltage is established by the voltage divider consisting of the resistors 55 end 56. Due to the switching over at the output from the operational amplifier 54, the transistor 57 is blocked so that the charging current from the current source 63 decreases towards 0 and with it also the adjustment since no longer any signal is delivered at the output from the multivibrator. Thus, the remaining adjustment can be omitted by reason of this snap op ration.

The entire circuit arrangement, up to the inductance 32, can be manufactured quite simply as an integrated circuit.

CLAIMS

1. An arrangement for the pressure-dependent adjustment of operating parameters of a combustion engine provided with an inductance variable in accordance with pressure and which together with a resistor forms a timing element the time constant of which is a measure of the pressure, characterised in that, a further timing element is provided the time constant of which is equal to the time constant of the pressure dependent timing element in its datum condition and that the pulses derived from the two timing elements and dependent on their time constants ere subtracted from one another.

2. An arrangement according to claim 1 characterised in that the timing elements are charged and discherged by means of electronic switches.

3. An arrangement according to claim 1 or 2 characterised in that comparators are connected beyond the timing elements and change their condition at a predetermined charging condition of the timing elements.

4. An arrangement according to claim 3 characterised in that a NAND element is connected beyond the comparators and effects a subtraction of the pulses delivered by the comparators.

5. An arrangement according to claim 4 characterised in that the pulse delivered by the NAND element is converted into a DC voltage by means of an integrating element.

6. An arrangement according to claim 5 characterised in that the DC voltage serves for controlling a multivibrator.

7. An arrangement according to claim 6 characterised in that the pulse length of the multivibrator is varied by controlling a current source of a transistor branch of the multivibrator.

8. An arrangement according to one of the preceding claims characterised in that a combination of a resistor and a capacitor serves as the further timing element.

9. An arrangement according to one of the preceding claims characterised in that a clock generator is provided which opens and closes the electronic switches.

10. An errangement according to claim 9 characterised in that the cl ck generator is externally controlled.

11. A device for adjusting an operating parameter of a combustion engine, substantially as herein described with reference to Figs. 1 and 2 of the accompanying drawings.

12. An ignition system provided with a

devic in accordance with claim 11, substantially as herein described with reference to Figs. 3 and 4 of the accompanying drawings.

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